REMARKS/ARGUMENTS

Status of the claims:

Claims 1 – 35, 48, 49, 56, 57, 59, 69 – 87, 94 – 129, and 130 are cancelled.

Claims 36 – 47, 50 – 55, 58, 60 – 68, 88 – 93, and 131 – 138 are pending.

Claims 36 – 47, 50 – 55, 58, 60 – 68, 88 – 93, and 131 stand rejected under 35 U.S.C. § 103(a).

Claims 36, 38, 39, 40, 43, 44, 50, 60, 63, 68, 88, 89 and 131 are presently amended.

Claims 132 – 138 are new claims.

Amendments to the claims:

No new matter has been introduced by way of new claims or claim amendments.

Independent claim 36 has been amended to include a limitation on the amount of aryl moiety bonded to the carbon nanotube surface. The limitation of sidewall functionalization at non-defect sites has been removed from claim 36. Support for the amendment to claim 36 is found on page 13, lines 13 – 14; page 13, Table 2; page 16, lines 12 – 15; and page 16, lines 30 – 31.

Independent claim 38 has been amended to include a limitation to an aryl diazonium specie. Independent claim 38 has been amended to include a limitation on the amount of aryl moiety bonded to the carbon nanotube surface. The limitation of sidewall functionalization at non-defect sites has been removed from claim 38. Support for the amendments to claim 38 is found on page 13, lines 13 – 14; page 13, Table 2; page 16, lines 12 – 15; and page 16, lines 30 – 31.

Independent claim 68 has been amended to include a limitation on the amount of aryl moiety bonded to the carbon nanotube surface. The limitation of sidewall functionalization at non-defect sites has been removed from claim 68. Support for the amendment to claim 68 is

found on page 13, lines 13 – 14; page 13, Table 2; page 16, lines 12 – 15; and page 16, lines 30 – 31

Independent claim 88 has been amended to include a limitation that electrochemically reacting comprises bonding an aryl moiety to the surface of the carbon nanotubes comprising the assembly at cross points of the first plurality of carbon nanotubes and the second plurality of carbon nanotubes. The limitation of fostering a sidewall reaction has been removed from claim 88. Support for the amendment to claim 88 is found on page 17, lines 36 – 38 and page 18, lines 1 – 6.

Independent claim 89 has been amended to further describe the assembly as a first plurality of carbon nanotubes and a second plurality of carbon nanotubes that can be individually addressed electronically. Independent claim 89 has been amended to state that applying the potentials to the assembly causes the first plurality of carbon nanotubes and the second plurality of carbon nanotubes to essentially come into contact. Independent claim 89 has been amended to include limitations that electrochemically reacting comprises bonding a first or second aryl moiety to the surface of the carbon nanotubes comprising the assembly at cross points of the first plurality of carbon nanotubes and the second plurality of carbon nanotubes The limitation of fostering a sidewall reaction has been removed from claim 89. Support for the amendments to claim 89 is found on page 17, lines 23 – 38; page 18, lines 1 – 6; page 18 lines 19 – 23, and the structures shown in Figure 1.

Claim 39 has been amended to provide a limitation to an aryl diazonium specie. Support for the amendment to claim 39 is found at a minimum in the structures shown in Figure 1.

Claim 40 has been amended to remove an improper limitation from step (c) and change the verb in step (d).

Claim 43 has been amended to provide a limitation to an aryl diazonium specie. Support for the amendment to claim 43 is found at a minimum in the structures shown in Figure 1.

Claim 44 has been amended to provide a limitation to an aryl diazonium specie. Support

for the amendment to claim 44 is found at a minimum in the structures shown in Figure 1.

Claim 50 has been amended to correct an incorrect cross-reference to the parent claim.

Claim 60 has been amended for stylistic purposes to parallel language in the parent claims and improve clarity of the claim description.

Claim 63 has been amended to replace 'functional' with the more specific term 'aryl.' Support for the amendment to claim 63 is found on page 16, lines 9 – 12.

Claim 131 has been amended for stylistic purposes to parallel language in the parent claims and improve clarity of the claim description.

Cancelled claims:

Claim 59 has been cancelled. Limitations of this claim have been incorporated into independent claims 36, 38 and 68.

New claims:

Claims 132 – 138 are new claims. Support for new claims 132 – 138 is found on page 12, lines 25 – 26; page 16, lines 12 – 15, and Figure 8.

I. Rejection of Claims 36 – 47, 50 – 55, 58 – 68, 88 – 93, and 131 under 35 U.S.C. § 103(a)

Claims 36 – 47, 50 – 55, 58 – 68, 88 – 93, and 131 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Ruoff, *et al.* (U.S. Patent 5,547,748) (hereinafter "*Ruoff*"). To the extent that these rejections apply to the claims as amended herein, Applicant respectfully traverses these rejections in light of the following arguments.

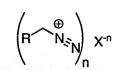
Applicant acknowledges withdrawal of Kelly as cited prior art.

Diazonium groups

The Examiner states that *Ruoff* teaches "nanomaterials functionalized by diazonium groups." Applicant respectfully traverses this statement.

As previously explained in the Response to Office Action of November 28, 2007, *Ruoff* teaches reactions of nanoencapsulates with diazoalkanes. The Applicant's disclosure describes reactions of carbon nanotubes with aryl diazonium salts. Diazoalkanes and diazonium salts are not equivalent chemical species as exemplified by representative structural formulas shown below in Figure 1. Although various resonance structures exist for both diazoalkanes and diazonium salts, no resonance structures render these two species equivalent.

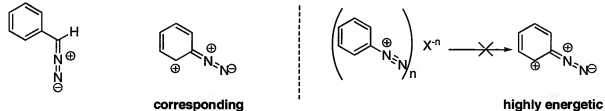
representative diazoalkane
R = alkyl or aryl



representative diazonium salt
R = alkyl or aryl
X^{-n} = Cl^-, Br^-, SO_4^{-2}, BF_4^-, PF_6^-, for example

Figure 1

A further consideration that distinguishes the two chemical species from one another is that diazoarenes (i.e., aryl diazo compounds) are not a stable chemical entity as shown below in Figure 2. The doubly bonded C=N=N group of a hypothetical diazoarene would require the 'C' to be part of the aromatic ring, thus breaking resonance stabilization of the aromatic ring in a highly energetically unfavorable process. Likewise, breaking of resonance stabilization precludes a hypothetical rearrangement of an aryl diazonium salt into a diazoarene.



benzyl diazoalkane

corresponding diazoarene
DOES NOT EXIST
(breaks resonance stabilization)

aryl diazonium salt

highly energetic structure
(rearrangement disfavored)

Figure 2

Diazoalkanes possess entirely different chemical reactivity from aryl diazonium salts.

Ruoff teaches that diazoalkanes may undergo a cycloaddition reaction with the carbon nanoencapsulates. Such a cycloaddition reaction incorporates nitrogen from the diazo group into the final product as exemplified in a representative reaction shown in Figure 3 below. As described in the Applicant's disclosure, aryl diazonium compounds lose dinitrogen to form a more reactive chemical species, which may be an aryl radical or an aryl cation (page 14, lines 31 – 38). Accordingly, nitrogen from the diazonium group is not incorporated into the final product as exemplified in a representative reaction shown in Figure 3 below.

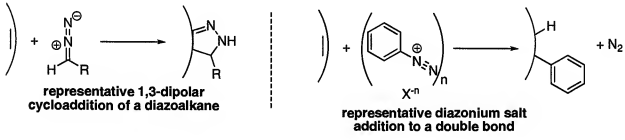


Figure 3

In summary, *Ruoff* does not teach aryl diazonium salt chemistry. Applicant therefore asserts patentability of Claims 36 – 47, 50 – 55, 58 – 68, 88 – 93, and 131 in this regard over *Ruoff*.

Examiner's statement that carbon nanotubes are an obvious expedient from Ruoff

The Examiner has stated that *Ruoff* suggests carbon nanotubes by "teaching of curved surfaces having pentagons in the sheet." The Examiner has further stated that carbon nanotubes are "an obvious expedient" from *Ruoff's* teaching. Applicant respectfully traverses these assertions.

Carbon nanotubes may have end-caps embodying features of a fullerene, such as both pentagons and hexagons that impart curvature and allow closure of the ends of the carbon nanotubes. The curvature imparts chemical reactivity to the end-caps. Carbon nanotubes have sidewalls that do not embody features of a fullerene. Reactivity of carbon nanotube sidewalls is similar to that of a graphene lattice. Carbon nanotube sidewalls are well known to be an sp^2

hexagonal graphitic lattice not containing pentagons. Hypothetical incorporation of pentagons into a carbon nanotube sidewall constitutes a defect site that would change the shape, properties, and reactivity of the carbon nanotube. Carbon nanotubes having non-defect sidewalls are well known and were used by the Applicant. Applicant respectfully asserts that *Ruoff* does not teach derivatizing carbon nanotube sidewalls as discussed below.

Ruoff clearly teaches that pentagons result in strain, which gives nanoencapsulates their reactivity. For example, the following are direct quotations from *Ruoff*.

Column 8, lines 45 – 51: "The presence of pentagons is key to the reactivity of simple fullerenes such as C_{60} and C_{70} (Taylor, 1991, 1992b). The pentagons introduce strain into the system and make possible a variety of nucleophilic, radical, and electrophilic addition reactions. As mentioned above, an important feature of the carbon nanoencapsulates is the sharp corners, which are likely to be reactive." (emphasis added).

Column 8, lines 35 – 38: "The strain at the bends, or corners, results in these areas being more reactive than the flat sides of the pentahedron."

Column 3, lines 4 – 7: "In other embodiments, the carbon shell of the nanoencapsulate is derivatized with a molecule. For example, the corners of the carbon shell, which are likely reactive, are covalently modified with appropriate functional groups." (emphasis added)

Column 8, lines 52 – 54: "Similiary, nanoencapsulates may be reactive at the strained corners, enabling the nanoencapsulate to be derivatized or functionalized with a wide variety of molecules."

Ruoff implies in these statements that nanoencapsulates are functionalized at pentagon-containing sites having sharp corners or bends. *Ruoff* goes on to state that nanoencapsulates have hexagonal graphitic lattices (column 7, line 43) but is silent on their reactivity.

Thus, there is no teaching in *Ruoff* to suggest that derivatization may be conducted on carbon nanotube sidewalls.

Further, Applicant's product by process provides aryl moiety bonding to a carbon nanotube, wherein there is at least about one aryl moiety to forty carbon atoms on the carbon nanotube surface after derivatization, as supported in Applicant's specification. Although Applicant's product by process may derivatize carbon nanotube end-caps, the observed level of aryl moiety bonding of at least about one aryl moiety to forty carbon atoms on the carbon nanotube surface, cannot be reconciled by exclusive reaction of a diazonium specie at pentagon sites on the carbon nanotube end-caps. Applicant's carbon nanotubes have diameters that provide end-caps of approximately the same diameter as C_{60}. End-caps of this size simply do not provide sufficient pentagon sites to support the observed level of derivatization. Thus, derivatization may have occurred elsewhere on the carbon nanotube, either in whole or in part, such as the carbon nanotube sidewalls.

Since *Ruoff* does not teach derivatization of carbon nanotube sidewalls as discussed hereinabove, Applicant asserts patentability of Claims 36 – 47, 50 – 55, 58 – 68, 88 – 93, and 131 over *Ruoff*. In particular, Applicant asserts that the level of derivatization embodied in claim 59 makes this claim patentable. Although Applicant believes that the arguments presented hereinabove are sufficient to justify patentability in their own right, in the interest of expediting prosecution, Applicant has amended the claims to provide a limitation of a minimal amount of aryl moiety derivatization.

Examiner's statement that Ruoff teaches nanotubes functionalized by aryl radicals

The Examiner has stated that *Ruoff* teaches "nanotubes functionalized by aryl radicals." Applicant respectfully traverses this statement.

Ruoff's reference to aryl radicals is directed to reactions at strained corners and bends of nanoencapsulates (*Ruoff*, column 8; lines 52 – 60). Based on the same arguments presented in detail hereinabove, *Ruoff* provides no suggestion to utilize aryl radicals for reaction at carbon nanotube or nanoencapsulate sites not containing pentagons. Likewise, *Ruoff* does not provide a reasonable expectation of success for carbon nanotube or nanoencapsulate derivatization with aryl radicals at sites not containing pentagons.

Since *Ruoff* does not teach functionalization of carbon nanotubes with aryl radicals as discussed hereinabove, Applicant asserts patentability of Claims 36 – 47, 50 – 55, 58 – 68, 88 – 93, and 131 over *Ruoff*.

Localization of Functionalization

The Examiner has stated that "localization of functionalization is deemed possessed or an obvious expedient, even though reaction is preferentially at the ends where the pentagons are, the claim only requires reaction at one site." Independent claims 36, 38, 68, 88 and 89 have been amended in response to this statement as detailed below.

Claims 36, 38 and 68: Claims 36, 38, and 68 describe a product by process wherein a plurality of carbon nanotubes or single wall carbon nanotubes are reacted with an aryl diazonium specie. Applicant has amended claims 36, 38 and 68 in response the Examiner's statement above, as supported by the specification, to provide a limiting amount of aryl moiety derivatization on the carbon nanotube surface.

Claim 36 as currently amended reads:

36. A product made by the process comprising:
    (a) selecting a plurality of carbon nanotubes; and
    (b) reacting the plurality of carbon nanotubes with an aryl diazonium specie to form carbon nanotubes derivatized with an aryl moiety, wherein reacting comprises bonding said aryl moiety to the carbon nanotube surface carbon atoms, wherein there is at least about one aryl moiety to forty carbon atoms on the carbon nanotube surface.

Claim 38 as currently amended reads:

38. A product made by the process comprising:
    (a) selecting an assembly of single-wall carbon nanotubes;
    (b) immersing the assembly in a solution comprising an aryl diazonium specie; and

(c) applying a potential to the assembly to electrochemically react the assembly with the aryl diazonium specie, wherein electrochemically reacting comprises bonding an aryl moiety to the carbon nanotube surface carbon atoms, wherein there is at least about one aryl moiety to forty carbon atoms on the carbon nanotube surface.

Claim 68 as currently amended reads:

68. A solution of single-wall carbon nanotubes made by the process comprising:

(a) providing a plurality of derivatized single-wall carbon nanotubes, wherein:

(i) an aryl diazonium specie derivatized the plurality of single-wall carbon nanotubes with an aryl moiety bonded to the carbon nanotube surface carbon atoms; and

(ii) there is at least about one aryl moiety to forty carbon atoms on the carbon nanotube surface; and

(b) mixing the plurality of derivatized single-wall carbon nanotubes in a solvent, wherein the derivatized plurality of carbon nanotubes are dispersed in the solvent.

Ruoff does not teach or suggest all of the limitations of claims 36, 38 or 68 as amended. In particular, at a minimum, *Ruoff* does not teach or suggest a limiting amount of aryl moiety derivatization on the carbon nanotube surface, which may include the sidewalls. The Examiner is reminded that all claim limitations must be taught or suggested by the prior art to establish obviousness. *In re Royka,* 490 F.2d 981, 180 U.S.P.Q. 580 (C.C.P.A. 1974). Applicant asserts that the claim amendments address all of the Examiner's comments and make claims 36, 38 and 68 patentable over *Ruoff* under 35 U.S.C. § 103(a). Claims 37, 39 – 47, 50 – 55, 58, 60 – 67, and 131 – 138 depend either directly or indirectly on claims 36, 38 or 68 and are patentable for at least the same reasons. *In re Fine,* 837 F.2d 1071, 5 U.S.PQ.2d 1596 (Fed. Cir. 1988). Withdrawal of the Examiner's rejection of claims 36 – 47, 50 – 55, 58, 60 – 68, and 131 under 35 U.S.C. § 103(a) in view of these amendments and the arguments presented hereinabove is respectfully requested.

Claims 88 and 89:

Claims 88 and 89 describe a product by process wherein an assembly comprising a first plurality of carbon nanotubes and a second plurality of carbon nanotubes may be derivatized with an aryl diazonium specie, wherein the first plurality of carbon nanotubes and the second plurality of carbon nanotubes may be independently addressed electronically. As described in the Applicant's disclosure, applying a potential to the assembly results in contact of a first plurality of carbon nanotubes with a second plurality of carbon nanotubes. Claims 88 and 89 have been amended to provide a limitation that derivatization with aryl moieties occurs at the cross points of the assembly between the first plurality of carbon nanotubes and the second plurality of carbon nanotubes.

Claim 88 as currently amended reads:

88. A product made by the process comprising:
    (a) preparing an assembly, wherein
        (i) the assembly comprises a first plurality of carbon nanotubes and a second plurality of carbon nanotubes; and
        (ii) wherein the carbon nanotubes in the first plurality and the carbon nanotubes in the second plurality can be individually addressed electronically;
    (b) immersing the assembly in an aryl diazonium specie;
    (c) applying a negative potential to the assembly to cause the first plurality to essentially come in contact with the second plurality; and
    (d) electrochemically reacting the assembly with the aryl diazonium specie, wherein electrochemically reacting comprises bonding an aryl moiety to the surface of the carbon nanotubes comprising the assembly at the cross points of the first plurality and the second plurality.

Claim 89 as currently amended reads:

89. A product made by the process comprising:
    (a) preparing an assembly of carbon nanotubes, wherein
        (i) the assembly comprises a first plurality of carbon nanotubes and a second

plurality of carbon nanotubes; and

(ii) wherein the carbon nanotubes in the first plurality and the carbon nanotubes in the second plurality can be individually addressed electronically;

(b) immersing the assembly in a first aryl diazonium specie;

(c) applying a potential to the assembly in a first direction to cause the first plurality to essentially come in contact with the second plurality;

(d) electrochemically reacting the assembly with the first aryl diazonium specie, wherein electrochemically reacting comprises bonding a first aryl moiety to the surface of the carbon nanotubes comprising the assembly at the cross points of the first plurality and the second plurality;

(e) immersing the assembly in a second aryl diazonium specie;

(f) applying a potential to the assembly in a second direction to cause the second plurality to essentially come in contact with the first plurality; and

(g) electrochemically reacting the assembly with the second aryl diazonium specie, wherein electrochemically reacting comprises bonding a second aryl moiety to the surface of the carbon nanotubes comprising the assembly at the cross points of the first plurality and the second plurality.

Ruoff does not teach or suggest all of the claim limitations of claims 88 and 89 as amended. In particular, at a minimum, nowhere in *Ruoff* is it taught or suggested that: 1) nanoencapsulates or carbon nanotubes may be prepared as an assembly; 2) a prepared assembly may be altered through applying a potential to cause contact between members of the assembly; and 3) nanoencapsulates or carbon nanotubes in an assembly may be reacted at cross points of contact. The Examiner is reminded that all claim limitations must be taught or suggested by the prior art to establish obviousness. *In re Royka,* 490 F.2d 981, 180 U.S.P.Q. 580 (C.C.P.A. 1974). Applicant asserts that the claim amendments address all of the Examiner's comments and make claims 88 and 89 patentable over *Ruoff* under 35 U.S.C. § 103(a). Claims 90 – 93 depend either directly or indirectly on claims 88 and 89 and are patentable for at least the same reasons. *In re Fine,* 837 F.2d 1071, 5 U.S.PQ.2d 1596 (Fed. Cir. 1988). Withdrawal of the Examiner's

rejection of claims 88 – 93 under 35 U.S.C. § 103(a) in view of these amendments and arguments presented hereinabove is respectfully requested.

Summary

In conclusion, *Ruoff* does not teach:

1) aryl diazonium chemistry,

2) functionalization of nanoencapsulates (or carbon nanotubes) at sites not having a sharp bend or corner,

3) functionalization of nanoencapsulates (or carbon nanotubes) with aryl radicals at sites not having a sharp bend or corner,

4) preparing an assembly of nanoencapsulates (or carbon nanotubes),

5) altering a prepared assembly of nanoencapsulates (or carbon nanotubes) to cause contact between members of the assembly, or

6) reacting an assembly of nanoencapsulates (or carbon nanotubes) at cross points of the assembly.

Applicant asserts patentability of the rejected claims over *Ruoff* under 35 U.S.C. § 103(a). In the interest of expediting prosecution of the application, Applicant has amended the claims to address Examiner's comments concerning the extent and localization of aryl moiety derivatization.

II. New Claims

Claims 132 – 138 have been added to provide further limitations to the removing step of claim 63. In particular, the removing step is limited to heating. The temperature ranges in these new claims is supported in the specification on page 12, lines 25 – 26; page 16, lines 12 – 15, and Figure 8. No new matter is introduced by way of the new claims.

CONCLUSION

No new matter has been added to the application by way of the claim amendments or

new claims. Applicant respectfully submits that claims 36 – 47, 50 – 55, 58, 60 – 68, 88 – 93, and 131 – 138 as they now stand amended are patentably distinct over the cited prior art and are in a condition for allowance.

If additional fees are due and are not included, the Director is hereby authorized to charge any fees or credit any overpayment to Deposit Account No. 23-2426 of Winstead PC (referencing matter 11321-P022WUD1). If the Examiner has any questions or comments concerning this paper or the present application in general, the Examiner is invited to call the undersigned at (713) 650-2780.

Respectfully submitted,

WINSTEAD PC

Attorneys/Agents for Applicant

Date: July 15, 2008

By: /sarah s. bittner/
Robert C. Shaddox, Reg. No. 34,011
Sarah S. Bittner, Reg. No. 47,426

Mail correspondence to :

WINSTEAD P.C.
P. O. Box 50748
Dallas, Texas 75201
Tel: 713.650.2764
Fax: 214.745.5390

Houston_1\977655\3
11321-P022WUD1 7/15/2008